

# Monitoring and Mitigration of N2O Emisssions: An Example from a Wastewater Treatment Facility

**Domingo-Felez, Carlos; Jensen, Marlene Mark**

*Publication date:*
2017

*Document Version*
Publisher's PDF, also known as Version of record

# Monitoring and mitigation of $N_2O$ emissions: An example from a wastewater treatment facility

Sara Ekström, A. Katrine Vangsgard, Romain Lemaire, **Carlos Domingo-Félez**, **Marlene M. Jensen**, Borja Valverde-Pérez, Benedek G. Plósz, Dines Thornberg & Barth F. Smets

## 1 Introduction

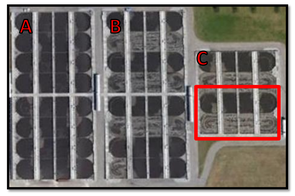
Nitrous oxide ($N_2O$) is an unwanted byproduct during biological N conversion processes in wastewater treatment (WWT), due to its large radiative forcing properties and stratospheric ozone depletion potential[1,2]. In total, 1.2% of the anthropogenic $N_2O$ emission is believed to originate from the WWT sector.

Only few detailed long-term $N_2O$ monitoring campaigns have been done to quantify $N_2O$ dynamics at reactor-scale from conventional nitrogen removal technologies. Here, we present results from a 1 year long $N_2O$ monitoring campaign at ***Lynetten***, the largest municipal WWT plant in DK.

Based on $N_2O$ measurements and analysis of the plant performance two control strategies were tested to mitigate the $N_2O$ emissions from the WWT plant.

## 2 How to measure $N_2O$ production and emission

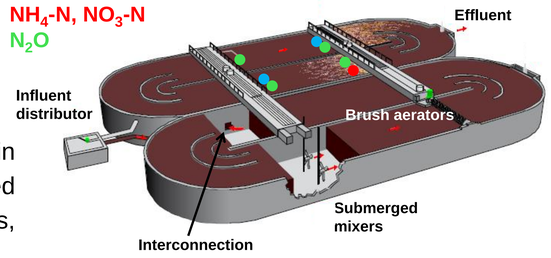
BioDenipho™ reactors



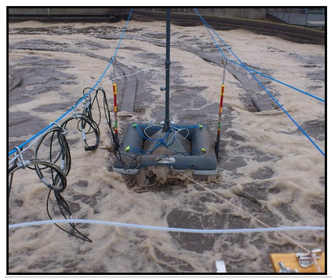

Biological nitrogen removal takes place in 20 interconnected surface aerated reactors by changing process conditions, as well as influent and effluent flows.
The reactors were very well mixed.

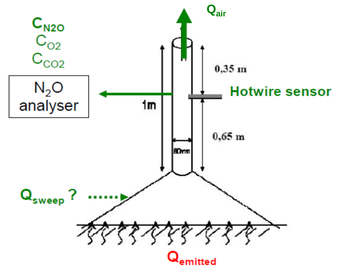
Liquid phase $N_2O$ measurements

Online sensors:
DO
$NH_4$-N, $NO_3$-N
$N_2O$




Gaseous phase $N_2O$ measurements: Flux-chamber technique



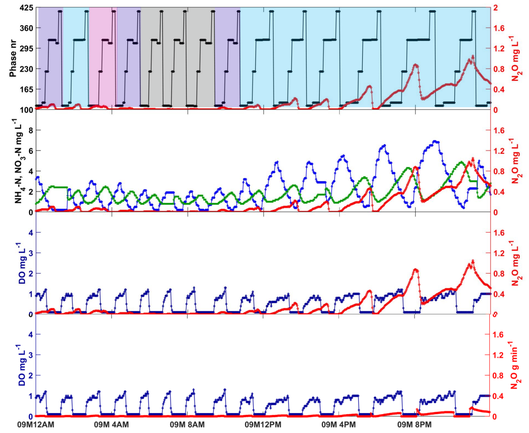



$$k_L a_{N_2O} = \frac{\frac{Q_{air} \cdot p_{N_2O}}{R \cdot T} \cdot MW_{N_2O}}{V_R \cdot (C_{N_2O-N} - C_{N_2O-N}^{*})}$$

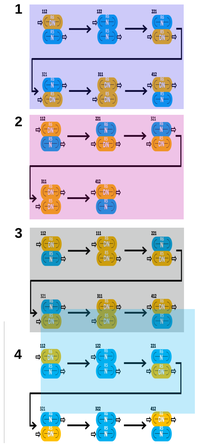
## 3 Daily operation has an impact on $N_2O$ production

$N_2O$ production and nutrient concentrations depend on:

Daily patterns



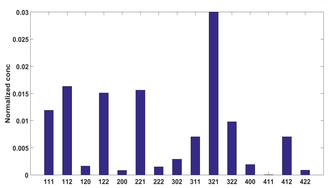

Operational strategies



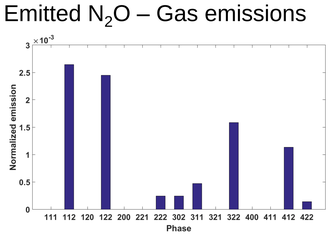

## 4 $N_2O$ production and emission variability

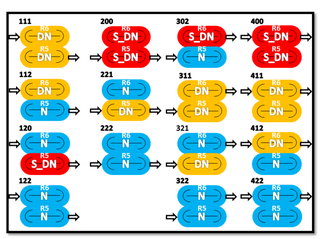
$N_2O$ emissions were associated to the plant operation strategy. Tentative mitigation strategies were proposed.

Dissolved $N_2O$ – Water discharge




Emitted $N_2O$ – Gas emissions

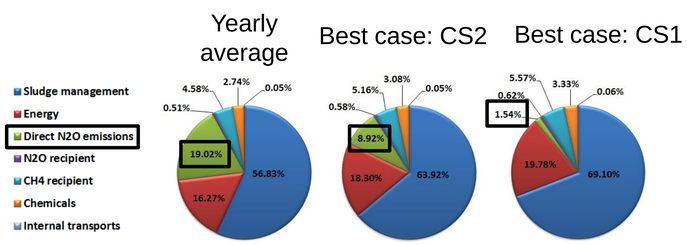



Distinct patterns between liquid and gas $N_2O$ emissions.

## 5 Test of $N_2O$ mitigation strategies

One-week campaigns were implemented and successfully lowered the $N_2O$ emissions by a factor of 12 fold of the yearly average.
Hence, decreasing the overall $CO_2$ footprint of the WWT plant.




| $N_2O$ emission factor | 0.6% of NLR | 0.25% of NLR | 0.04% of NLR |
|---|---|---|---|
| Parameter | $CO_2$ eq. t/y | $CO_2$ eq. t/y | $CO_2$ eq. t/y |
| Energy | 4414.6 | 4414.6 | 4414.6 |
| Sludge management | 15419.0 | 15419.0 | 15419.0 |
| $N_2O$ recipient | 138.7 | 138.7 | 138.7 |
| CH4 recipient | 1243.8 | 1243.8 | 1243.8 |
| Chemicals | 742.8 | 742.8 | 742.8 |
| Internal transports | 12.5 | 12.5 | 12.5 |
| $N_2O$ emission | 5162.0 | 2150.8 | 344.1 |
| Σ | 27133.54 | 24122.4 | 22315.71 |

## 6 Why is this work important?

- A method to quantify $N_2O$ emissions and the corresponding $CO_2$ footprint was developed.
- Long term monitoring showed that $N_2O$ peaks in the afternoon during high loads to the WWTP and that $N_2O$ was emitted during aeration phases.
- Total $N_2O$ emissions accounted for up to 0.8% of the nitrogen load and ~30% of the total $CO_2$ footprint.
- Case study CS-1 yielded the highest reduction in $N_2O$ emission and best effluent wastewater quality (highest $NH_4^+$-N and $NO_3^-$-N removal). The total $CO_2$ footprint was reduced by ~18% compared to normal operation
- Current status: Mechanistic model calibration

*References*

(1): Bernstein L., Bosch P., Canziani O., Chen Z., Christ R., Riahi K (2008): *IPCC. 2007: Climate Change 2007: Synthesis Report.* IPCC. (2): Ravishankara A. R., Daniel JS., Portmann RW (2009): Nitrous oxide ($N_2O$): The dominant ozone-depleting substance emitted in the 21th century. *Science* 326 (5949): 123-125.

*Acknowledgments*

The work has been funded in part by the Innovation Fund Denmark (Project LaGas, File No. 0603-00523B), and Veolia Water Technology.

DTU Environment
Department of Environmental Engineering

DTU Environment
Department of Environmental Engineering

DTU Environment
Department of Environmental Engineering